DOCUMENT RESUME

ED 423 670 FL 025 447

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TITLE Vowel Mutability: The Case for Spanish.
PUB DATE 1998-03-00
NOTE 23p.; Paper presented at the Annual Meeting of the American Association for Applied Linguistics (20th, Seattle, WA, March 13- 17, 1998).
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Language Patterns; *Language Processing; Language Research; *Linguistic Theory; Native Speakers; *Phonology; *Spanish; Vocabulary; *Vowels
IDENTIFIERS Nonsense Words

ABSTRACT

Replicating research originally performed with native speakers of English, this study investigated the mutability of vowels in Spanish. The study was based on the theory that when presented with non-words, native speakers are more likely to change the vowel than the consonant to arrive at an existing lexical item. It was hypothesized that if English vowels are more mutable than consonants because of the structural characteristics of the language, then Spanish vowels should be less mutable. Subjects were 30 native speakers of Spanish from a variety of national backgrounds, all college-educated adults. They were presented with 60 non-words that could be changed into real Spanish words by altering one consonant or one vowel. The results did not match the prediction, and suggest that the size of the vowel repertoire or language-specific characteristics may not be the main factor. An alternative explanation for the mutability in vowels in word reconstructions may be that consonants impose more constraints on the possible real word solutions. (MSE)

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Vowel Mutability: The Case for Spanish

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Abstract

In 1996, van Ooijen introduced a new paradigm for investigating lexical processing. When she presented English listeners with non-words, they were more likely to change the vowel than the consonant to arrive at an existing lexical item. The study concluded that in English, vowels are more mutable than consonants because of structural characteristics of the language.

The present study replicates van Ooijen's (1996) with native speakers of Spanish in an attempt to separate structural differences from speech processing.

If vowels are more mutable than consonants because of the structural characteristics of English, then Spanish vowels should be less mutable. Our results do not match this prediction. Our finding suggests that the size of the vowel repertoire or language specific characteristics may not be the main factor. An alternative explanation for the mutability of vowels in word reconstruction may be that consonants impose more constraints on the possible real word selections.

Vowel Mutability: The Case for Spanish

A number of researchers have investigated the smallest discrete unit which enters into play when processing speech or recognizing spoken words. In speech comprehension, the syllable-sized unit has played a determining role; studies have concentrated on both English (Cutler & Norris, 1988; Cutler & Butterfield, 1990, 1992; among others) and French (e.g. Mehler, Dommergues, Frauenfelder, & Segui, 1981). In addition, researchers have also taken into consideration the role of the phoneme-sized unit; evidence from studies on phonemic misperceptions (e.g. Bond & Garnes, 1980; Garnes & Bond, 1980; MacKay, 1970) and from the existence of puns and rhyming games attest to the importance of the phoneme-sized unit in speech perception. Models of spoken word recognition have incorporated the phonemic level of representation (e.g. Marslen-Wilson's 1987, 1990 cohort model was one of the most widely accepted of these models). When recognizing speech, in this activation-based model, listeners use a bottom-up processing system whose onset is an acoustic-phonetic representation of the input. However useful they might be, these models have failed to address important differences between types of phonemes, namely vowels and consonants, which the literature in the field has determined. (Studies have found differences between vowels and consonants in categorical perception. See Liberman, Mattingly, & Turvey, 1972; or Studdert-Kennedy, Liberman, Harris, & Cooper, 1979, inter alia).

In this context, van Ooijen's (1996) study investigates the possibility that adult native speakers (NSs) of English process consonants and vowels in a different fashion. In her new paradigm for investigating lexical processing from a word reconstruction task, van Ooijen presented English listeners with non-words. She instructed them to change either a vowel or a consonant

(depending on the sound condition) to turn a non-word into a real word. For example, the non-word "athic" rendered either "ethic" or "attic" as possibilities. The results of van Ooijen's study showed that to arrive at an existing lexical item, these listeners were more likely to change the vowel than the consonant. This study concluded that vowels are more mutable than consonants in English because of structural characteristics of the language such as vowel reduction and dialectal variation (depending primarily on vowel differences). However, does the vowel mutability effect solely result from the structure of the language, as suggested by van Ooijen?

The present study replicates van Ooijen's (1996) research with native speakers of Spanish in an attempt to separate the effect of structural differences from those of speech processing. Van Ooijen hypothesized that adult English listeners would treat vowels as more mutable than consonants in auditory word recognition. Thus, if the vowel mutability effect is due to structural differences, then our results with Spanish will differ from van Ooijen's with English.

The English vowel inventory is larger than the Spanish (R.P. English has a total of 12 pure vowels and 8 glides) and weak, in the sense that it allows strong vowels to reduce to schwa. In comparison, the Spanish vowel inventory is considerably smaller than the English (Spanish contains 5 pure vowels and 2 glides. See Appendix A.) and strong since it allows no such reductions. English and Spanish also differ in other aspects. In English, vowels more clearly depict dialectal variations, whereas in Spanish, dialectal variations depend primarily on consonant differences.

The present study maintained the same three experimental conditions or independent variables of van Ooijen's (1996) word reconstruction task; namely, (a) A sound change made using either a vowel or a consonant (the E

condition), (b) A sound change made using only a vowel (the V condition), and (c) A sound change made using only a consonant (the C condition). In terms of dependent variables, we used the following: (a) Error rate, and (b) Proportion of vowel versus consonant responses.

Method

Participants

Thirty adult NSs of Spanish (13 Mexican; 2 Chilean; 3 Costa Rican; 1 Venezuelan; 2 Salvadorian; 4 Guatemalan; 1 Paraguayan; 1 Ecuadorian; and 3 Bolivian) all of whom speak standard American Spanish, as described by Barrutia and Schwegler (1994), Barrutia and Terrell (1982), or Teschner (1996), inter alia. (See Appendix A for a binary distribution chart of the phonemes in this dialect). These subjects were college educated adults (with an age range between 18 and 65) who were living in the US at the time of the study (the range in length of stay was between 2 months and 40 years).

Materials

Sixty non-words which could be changed into real Spanish words by altering one consonant or one vowel, as in "entena," "antena" or "entera."

The target lexical items were low frequency words, that is, words found at < 255 per 500,00, with the exception of one word at 427 (Juilland & Chang-Rodríguez, 1964). The mean frequencies for the real words resulting from a vowel change was 34.7 and the mean frequencies for the real words resulting from a consonant change was 34.1. In half of the materials, the word that resulted from the vowel change had a higher frequency of occurrence than the word that resulted from the consonant change. In the other half the reverse was the case.

Since Spanish is a highly inflected language, the target choices necessarily included inflected forms of words (which are more commonly used) as well as uninflected forms, such as consonant ending nouns. Thirty-four non-words had more than one possible vowel change, as in "tarre," which has "tarro" and "torre," versus "barre" as the only consonant word. Thirty-eight other non-words had more than one possible consonant change, as in "nimbre," which has the consonant words "mimbre" and "timbre" versus the vowel word "nombre." The total number of the possible real word alternatives was matched for the vowel versus the consonant words (115 vs. 135, respectively).

In accordance with the lexical statistics for Spanish (Justicia 1995), most words had the stress on the penultimate syllable (46 out of 60 items); also, more words started with either a consonant-vowel (CV) pattern or a consonant-vowel-consonant pattern (CVC) (18 and 16, respectively).

Vowel and consonant positions within the words were controlled as well as possible. In 31 of the 60 non-words, the consonant change occurred earlier than the vowel change; in the remaining 29, the vowel change preceded the consonant change.

Another factor that we took into consideration was the uniqueness point of the target words, that is, the point at which those words are fully distinct from all other words. We were looking for a balance so that the same number of vowel changes and consonant changes occurred before or after their recognition point. In our study, the uniqueness point remained constant in that the words were not identifiable until the last segment.

An additional 70 non-words (mostly trisyllabic with change needed toward the end of the word) were used as filler items; 12 of these served as practice items. The idea was to increase subject confidence to yield both

frequent and fast responses and to discourage subjects from utilizing a rhyming strategy.

The materials were recorded and annotated by one of the experimenters, a female NS of Spanish from Mexico whose dialect was the predominant one of the participants. To ensure an acoustic realization of each non-word that was as close as possible to both its alternatives, the speaker first pronounced both the vowel and the consonant real-word alternative, before each stimulus non-word, for example: "torre - barre - tarre." All experimental non-words with their corresponding vowel and consonant real words appear in Appendix B.

Design and Procedure

The 60 non-word items were divided into three groups of 20. In each of these groups, approximately 10 items had the consonant change prior to the vowel change and 10 had the vowel change prior to the consonant change. These groups of experimental items were alternated among the three sound change conditions in two randomizations. Therefore, all subjects heard all of the materials, but 10 heard a given set of 20 items in the vowel change condition (V condition), 10 heard the same set in the consonant change condition (C condition), and 10 heard it in the either sound change condition (E condition).

Subjects received taped instructions which stated that they were going to hear a non-word and that they were to say the first real word that they could think of. Subjects knew that there could be more than one possible real word for any given non-word item. They were asked to change a consonant (C condition), a vowel (V condition), or either sound (E condition) depending on the condition they were in. Nevertheless, they were not made aware prior

to the experiment that they were going to change categories. The order of presentation of the three sound conditions was counterbalanced so that all subjects heard the material in the same order, but half of them started with consonant change instructions, 10 with vowel change instructions, and 10 with either sound instructions. There were 12 items divided into three groups based on the sound change condition which served as practice items for the subjects to try before the experiment. The experimenter controlled the presentation of the stimuli with a time out of 10 sec. In all, each individual experiment took approximately 30 minutes.

Results

Errors in the Subject Analysis

Responses were scored for errors, which were defined as no response in the allotted 10-second interval, intrusions (vowel responses given in the C condition or consonant responses given in the V condition), and mistakes (responses involving a change of more than one phoneme or involving a change of stress). Mean errors for the E, V, and C conditions, averaged across subjects, are shown in Table 1.

A multivariate analysis of variance (MANOVA) was first conducted on the subject data. The main effect for condition was significant, $F(2,56) = 37.61$, $p<.001$. The main effect for randomization was not significant, $F(1,28) = .19$, $p>.05$, though the interaction between condition and randomization approached significance, $F(2, 56) = 2.81$, $p<.07$. With errors collapsed across randomizations, t tests showed consonant errors ($M = 10.77$) to be significantly larger than errors in the E condition ($M = 5.80$), $t(29) = 6.51$, $p < .001$. Similarly, consonant errors ($M = 10.77$) were also significantly larger than vowel errors

(M = 6.23), t (29) = 7.39, p< .001. Either sound errors (M = 5.80), however, were not significantly different from vowel errors (M = 6.23), t(29) = .76, p>.05.

Errors in the Item Analysis

A MANOVA was then performed on the item data. The pattern of results for the item analysis was the same as that for the subject analysis. Means and standard deviations for errors are shown in Table 2.

The main effect for condition was significant, F (2,236) = 31.15, p<.001. The main effect for randomization was not significant, F (1,118) = .50, p>.05. The interaction between condition and randomization was nearly significant, F (2, 236) = 2.95, p = .054. With errors collapsed across randomizations, consonant errors (M = 0.53) were significantly greater than either sound errors (M = 0.30), F (1,118) = 60.32, p<.001. Similarly, consonant errors (M = 0.53) were also significantly greater than vowel errors (M = 0.31), F (1,118) = 31.91, p<.001. Either sound errors (M = 0.30), however, did not differ significantly from vowel errors (M = 0.31), F (1,118) = 0.27, p>.05. The fact that the significant effects were reliable across both subject and item analyses indicates that these results will generalize to other samples of subjects and items drawn from the same populations. Where participants had a choice of which sound to change (E condition), they preferred to change a vowel rather than a consonant. The number of vowel changes (M = 8.8) was significantly greater than the number of consonant changes (M = 5.4), t (29) = 4.44, p<.001. This indicates that our Spanish listeners treated the E condition almost as if it were a V condition.

Types of Errors

A related question asked whether the three types of errors were distributed evenly across conditions. A 2 x 3 ANOVA having condition

(consonant, vowel) and type of error (no response, intrusion, mistake) was performed on the subject data. The main effect for condition was significant, F (1, 174) = 28.52, $p<.001$, as was the main effect for type of error, F (2, 174) = 38.08, $p<.01$. The interaction was also significant, F (2, 174) = 3.64, $p<.03$. Means and standard deviations for the six conditions are shown in Table 3.

Tukey HSD posttests revealed the mean for the no response error in the C condition (5.83) to be significantly higher than all other means. Also, the mean number of mistakes in the C condition (3.07) was significantly higher than the mean number of intrusions in the V condition (0.70), and the mean number of no response errors in the V condition (3.13) was also significantly higher than the mean number of intrusions in the V condition (0.70), all $ps<.05$.

In the E condition only no response errors and mistakes were relevant. The mean number of no response errors was 2.93 (SD = 2.12) and the mean number of mistakes was 2.77 (SD = 1.50). These means were not significantly different, t (58) = .35, $p>.05$.

Errors in the C condition were significantly higher than in the V condition. Subjects made no response type of errors predominantly or if they could not think of a word, they would make an intrusion.

Discussion

This study replicates van Ooijen's (1996) with some obvious differences between the two. Our study focused on Spanish and most of its real words displayed a relatively low frequency. Potentially confounding variables were well controlled except for the number of real word choices where, due to the specific characteristics of the language, this number is significantly greater for the consonants than it is for the vowels. Nevertheless in our study the error

rates are consistently lower than in van Ooijen's and the limits of the three experimental conditions are less clearly differentiated, that is, the subjects basically treated the E condition as if it were a V condition.

However, both studies found evidence for the mutability of vowels. Van Ooijen (1996) designed a word reconstruction experiment to test the hypothesis that English listeners will assume vowel identity to be more mutable than consonant identity. She based her prediction in the findings of word-spotting and word recognition experiments that have a perceptual basis. Her esults showed that the participants substituted strong vowels more readily than consonants to turn non word stimuli into real words. Van Ooijen proposes that "the observed mutability of vowels is indicative of a mechanism for dealing with expected uncertainty about precise vowel identity" (p. 579).

In our study with Spanish listeners and contrary to our original predictions based on the structure of the language, vowels were more mutable than consonants in word reconstruction tasks. This finding matches the results in van Ooijen's study in terms of error patterns. However, it does not support its conclusions. Spanish is a very vowel-sparse language and one would expect vowels to be less mutable perceptually than in English. However, the participants in our study preferred to change vowels than consonants.

Our finding suggests that the size of the vowel repertoire or language specific characteristics may not be the main effect at play. One explanation for the mutability of vowels may be that consonants impose more constraints on the possible target word selections than vowels because they lock words in the mental lexicon.

A factor to take into consideration is bilingual versus monolingual speakers. Our subjects were Spanish-English bilinguals who functioned in an English-speaking environment. Their knowledge of English may have affected their Spanish.

Conclusion

This study renders full support to the mutability of vowels in word reconstruction tasks. Although this finding matches the results in van Ooijen's (1996) study, which we set to replicate, it does not support its conclusions. Even though Spanish is a vowel-sparse language, the participants in our study (30 Spanish-English bilingual speakers) preferred to change vowels than consonants.

As we mentioned in the discussion section, one plausible explanation for the mutability of vowels may be that consonants lock words in the mental lexicon since they impose more constraints on the target word selections. This finding supports our idea that the size of the vowel repertoire or language specific characteristics may not be the main effect at play.

Another plausible explanation may be that vowel mutability is a language universal processing strategy. This hypothesis invites studies in many other languages with different vowel inventories as well as employing different orthographies.

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Appendix A

Sounds of Standard American Spanish

Consonants: The 17 Spanish consonant phonemes

graphemes	phonemes	allophones	articulatory description
p	/p/	[p]	bilabial
b,v	/b/	[b] stop [ß] fricative	bilabial labiodental
m	/m/	[m] [μ]	bilabial labiodental
f	/f/	[f]	labiodental
t	/t/	[t]	dental
d	/d/	[d] stop [ð] fricative	dental dental
n	/n/	[m] [μ] [n̪] [n] [n̠] [ñ] [n̩]	bilabial labiodental dental alveolar palatoalveolar palatal velar
s, z, c	/s/	[z] voiced [s] voiceless	alveolar alveolar
l	/l/	[l]	alveolar
r	/r/	[r] tap	alveolar
r, rr	/r̠/	[r̠] trill	alveolar
ch	/c/	[ĉ]	palatoalveolar
ñ	/ñ/	[ñ]	palatal
c, qu, k	/k/	[k]	velar
g, gu	/g/	[g] stop [g] fricative	velar velar
j, g	/x/	[x]	velar
y	/j/	[j], [ž], [ĵ]	palatal

Vowels:

The two Spanish glides

graphemes	phonemes	allophones	articulatory description
i/y	/j/	[j]	palatal
u	/w/	[w]	labialized velar

The five Spanish vowel phonemes

graphemes	phonemes	allophones	articulatory description
i,y	/i/	[i]	high, anterior
e	/e/	[e]	medial, anterior
a	/a/	[a]	low, central
o	/o/	[o]	medial, posterior
u	/u/	[u]	high, posterior

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Appendix B

Spanish Word List

Stimuli	*Consonant change*	*Vowel change*
entena	entera	antena
volor	color, dolor	valor, volar
umita	uvita, huchita, uñita, humilla	amita, emita, imita, omita, humito
tarsa	farsa, tarda, tarta	tersa, tuerza
astera	altera, azteca	estera, austera
plecas	plenas	placas
quieva	nieva, quiera, quieta	cueva, Cuba, cava
indas	(h)incas, hinchas	andas, ondas, hundas
rista	lista, pista, vista	resta
boción	loción, moción, noción	visión
arror	amor, arroz	error, horror
bundos	mundos, burdos	bandos
mantar	cantar, manchar mandar, manjar	mentar, montar
jurro	burro, zurro, jugo	jarro
panente	patente, palente	ponente
lecha	fecha, mecha, techa	leche, lecho
pador	pavor	pudor
apuyo	arrullo, apuro	apoyo
nimbre	mimbre, timbre	nombre
placo	flaco, plano, plato, plazo	placa
rizón	bisón, tizón, riñón	razón, rozón
heledo	heredo, elevo, helecho	helado, elido, eludo
tingo	bingo, chingo	tango, tengo

pobra	cobra, sobra, potra	pobre
analo	avalo	anhelo, anulo
hurre	hule, huye, une, use	hurra, arre, erre
olma	horma	alma, olmo
ebla	hebra	habla
nirmar	firmar	normar
étoca	época	ética
minte	pinte, tinte	miente, mente, monte
ulga	hurga	alga
motal	total, modal, moral	motel
bocino	cocino, tocino, bovino	bocina
britar	gritar, brillar	brotar
fúnicas	púnicas, túnicas	fónicas
ecento	evento	acento
abeso	abeto	obeso, aviso, abuso
mendo	vendo, yendo	mando, mundo
eltima	estima	ultima
mulva	vulva, multa	malva, melva
flito	frito	flato, fleto, floto
pusa	lusa, musa, rusa, puja, puma, pura, puta	pausa, pasa, pisa, posa, puse, puso
impano	hispano, impago	empano
prema	preña, presa	prima
tarre	barre	tarro, torre
olijo	olivo	alijo, elijo
tunta	junta, punta, tumba	tanta, tinta, tonta
ápico	ático	épico, hípico

esfira	estira	esfera
osla	hosca, orla	isla
ayida	anida	ayuda
sul	tul, sur	sal, sol
cuarno	cuarzo, cuarto	cuerno
molor	color, dolor, motor	molar, moler
suerne	suerte	cierne
munta	junta, punta, multa	manta, menta, monta
conda	fonda, ronda, sonda	conde
robio	novio	rubio
custa	fusta, gusta, justa culta, curta	cuesta, casta, costa

Table 1

Means and Standard Deviations (in parentheses) for Errors in the Subject Analysis

	Condition		
Randomization	Sound	Vowel	Consonant
1	5.20	6.47	11.67
	(1.93)	(2.62)	(4.34)
2	6.40	6.00	9.87
	(2.32)	(2.86)	(3.40)
Combined	5.8 [9.7%]	6.23 [10.4%]	10.77 [18%]
	(2.19)	(2.70)	(3.94)

Table 2

Means and Standard Deviations (in parentheses) for Errors in Item Analysis

	Condition		
Randomization	Sound	Vowel	Consonant
1	0.27	0.33	0.59
	(0.29)	(0.32)	(0.30)
2	0.32	0.30	0.48
	(0.30)	(0.32)	(0.30)
Combined	0.30	0.31	0.53
	(0.29)	(0.32)	(0.30)

Table 3

Means and Standard Deviations (in parentheses) for Types of Error across Conditions

	Type of Error		
Condition	No Response	Intrusion	Mistake
Consonant	5.83	1.93	3.07
	(2.88)	(2.29)	(1.78)
Vowel	3.13	.70	2.23
	(2.03)	(.92)	(1.33)